State of California
DEPARTMENT OF TRANSPORATION

Business, Transportation and Housing Agency

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Memorandum

To: MS. OFELIA ALCANTARA
District Office Chief
Bridge Design West
Division of Structures Design

Date: March 5, 2008

Attention: S. Hamoud
S. Ly

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Widening/Realignment

From: M. ZABOLZADEH/ A. KADDOURA
Associate Materials & Research Engineer
Office of Geotechnical Design – West
Geotechnical Services
Division of Engineering Services

For HOOSHMAND NIKOUI
Chief, Branch A
Office of Geotechnical Design – West
Geotechnical Services
Division of Engineering Services

Subject: Foundation Report for Soil Nail Walls #1, #2, and #3

This report supersedes our previous report dated October 13, 2005 and presents our recommendations for the above referenced project. The recommendations contained in this report are based on the results from field mapping, subsurface investigations, and review of the available information in files.

I. SITE CONDITIONS/BACKGROUND

This project seeks to improve traffic safety along State Route 116 (Stage Gulch Road) in Sonoma County between the intersections of Adobe Road (KP 67.3, PM 41.8) and Arnold Drive (KP 71.9, PM 44.8). The existing facility is an undivided, 2-lane rural highway with 3 meter to 3.6 meter lanes, and 0 meter to 0.6 meter shoulders. This project would realign (in some areas) and widen the roadway to standard 3.6 m lanes and shoulders to 2.4 m standard width. As part of the realignment of the roadway near County Dump Road, a left turn pocket will be provided to service traffic on and off the County Dump Road.

To accommodate for the proposed roadway widening and realignment, a total of six retaining walls (3 Soil Nails Walls, 1 Standard Type 1 Walls, and 2 in the process of type

selection) are proposed to minimize cuts/fill and the need to acquire new State Right-of-Way.

This report only addresses the proposed Soil Nail Walls #1, #2, and #3 (SNW #1, SNW #2, and SNW #3).

II. REGIONAL GEOLOGY AND SEISMICITY

Sonoma County lies in the California Coast Ranges, a northwest-trending band of folded and faulted mountains that roughly parallel the San Andreas Fault Zone. The Coast Ranges consist of folded Tertiary sedimentary rocks, with minor metamorphic and volcanic components.

The Pliocene Sonoma Volcanics extend over about 3,200 km^2 in Sonoma and Napa Counties. They are about 1,500 meters thick. Andesitic and rhyolite flows make up the bulk of the section, along with tuffs and agglomerates.

The region is highly seismically active, with numerous active and potentially active faults. East of the San Andreas Fault Zone, the bedrock is the Cretaceous Franciscan Formation. The Rodgers Creek-Healdsburg Fault Zone is a major strike-slip fault in Sonoma County that controls seismic hazard for the site.

The soil/rock samples recovered show volcanic rock and volcanic rock weathered to sand- or silt-sized particles

Table 1 lists nearby faults, distances to the project site, maximum credible earthquake and estimated peak ground accelerations.

Table 1
Fault Data

Fault	Fault type	Minimum distance to project (km)	Maximum Credible Earthquake	PGA (g)
Rodgers Creek-Healdsburg	Right-lateral strike-slip	0	7	0.63
San Andreas	Right-lateral strike-slip	28	8	0.35
Hayward	Right-lateral strike-slip	28	7½	0.22

The Rodgers Creek Fault Zone crosses the project somewhere between Stations 22+00 and 26+00 at the location of Soil Nail Wall #2 (SNW #2). The roadbed can be easily repaired in the event of ground rupture along the fault.

IV. FOUNDATION SOIL AND GROUNDWATER

The Office of Geotechnical Design – West, a Division of Engineering Services, investigated the subsurface conditions (August 2004) at the site using Christensen CS 2000 track drill rig. The power borings were drilled using truck-mounted drill rig. Standard Penetration Tests (SPT) were performed on foundation soils.

The foundation investigation for these walls consisted of drilling four vertical borings (P-5, P-9, P-10, and P-11) and six horizontal borings (HB-1, through HB-6). The power borings describe the foundation soil in general as slightly to moderately weathered Tuff (volcanic ash) with fine to medium grain. The SPT blow counts range between 30 and more than 50 (refusal) blows per 0.3 m.

No groundwater was encountered in the power borings at the time of drilling.

LOTB sheets will be furnished upon completion.

V. RECOMMENDATIONS

To accommodate for the proposed widening by cutting into the adjacent hills, we have considered different types of retaining wall alternatives such as Caltrans Standard Type 1 and Type 7 Retaining Walls, and Soil Nail Wall. However, for this project, because of the geology of the adjacent hills, long and continuous cut slope above the proposed wall, and most importantly for seismic reasoning and ease of construction, we believe Soil Nail Wall would be the most feasible and economical alternative. Therefore, we recommend constructing Soil Nail Walls (SNW #1, SNW #2, and SNW #3) along the face of the proposed cuts. The approximate limits, lengths, and maximum heights of the walls are listed in Table 2 below. See attached Exhibit A for Typical Cross Section.

Table 2

Soil Nail Wall No.	Approximate Wall Limits	Length (m)	Maximum Height (m)
SW #1	Sta. A 23+79± to Sta. A 24 +75±	96	7.9±
SW #2	Sta. A 27+37± to Sta. A 28 +45±	108	9.0±
SW #3	Sta. A 30+44± to Sta. A 33 +06±	262	8.6±

A. Design Criteria for Soil Nail Walls

In this project, the design for the proposed soil nail walls is performed using the recently improved Caltrans' Computer Program "SNAILZWIN", Version 5.1.. The rock/soil parameters used in this program were selected based on the vertical and horizontal borings (See Attached LOTB sheets for details) drilled along and within the proposed wall limits, and field observations.

The following limiting criteria are used in the design of the SW #1, SW #2, and SW #3:

- The minimum factor of safety with seismic loading (pseudo-static): $FOS_{dynamic} = 1.0$; a horizontal pseudo-static coefficient of 0.20 g was used to simulate seismic loading conditions

- $FOS_{dynamic}$ = 1.0; a horizontal pseudo-static coefficient of 0.45 g was used to simulate seismic loading conditions.

- The minimum static factor of safety of staged construction: $FOS_{construction}$ = 1.3.

- The maximum spacing of the nails (S_v x S_h),
  S_v is the vertical spacing of the nails
  $S_{v,MAX}$ = 1.5 m
  S_h is the horizontal spacing of the nails
  $S_{h,MAX}$ = 1.5 m

- The inclination angle (θ) of all the nails to the horizontal = 15 degrees

- The average soil/rock design parameters used for design of each soil nail wall (based on the LOTB sheet) were:

  Friction Angle (ϕ) = 36 degrees
  Cohesion (c) = 12 kPa (200 psf)
  Unit Weight (γ) = 20.40 kN/ m^3

- Soil nail profiles lines shall be parallel to the top of the wall except the bottom most line, which shall be parallel to the bottom of the wall.

- Minimum and maximum vertical distances from the bottom of the wall to the bottom level of the soil nail assembly (SB) shall be 0.5 m and 1.0 m, respectively.

- Soil nails shall be of ASTM Designation: A615M, Grade 420, fs= 420 MPa and #29 bars.

- Pullout resistance between grout and drilled hole = 43 kN per linear meter of bonded length.

- Punching shear capacity = 180 kN.

- The vertical distance between the bottom of the wall and the finished grade of the proposed bench = 0.5 m.

- Vertical distance between top of wall (cut line as shown on the plans) and the top most row of soil nails ST = 0.60 m.

- Minimum and maximum spacing, both horizontal and vertical, of soil nail assembly = 0.5 m and 1.5 m, respectively.

- Minimum and maximum distances between the beginning/end of wall and the first/last soil nail = 0.5 m and 0.75 m, respectively.

- The designed lengths (embedment depth) of the soil nails will be shown on the proposed Soil Nail Retaining Wall Plans.

B. Field Testing

Field verification of the design pullout resistance values used in the design ensures that the nail design loads can be carried without excessive movements and with an acceptable factor of safety for the service life of the wall. Verification testing and proof testing shall be conducted in order to verify the design pullout resistance and to ensure consistency of the quality of drilling, installation and grouting technique.

Verification testing and stability testing for each " wall zone" shall be conducted prior to the installation of production soil nails in accordance to the special provisions at locations recommended by the Engineer. It is recommended that locations for these tests be shown in the Contractor's working drawing submittal for approval. The wall zones shall be defined as follows:

Soil Nail Wall #1

Zone	Begin Stationing	End Stationing	Upper Elev.	Lower Elev.
1	23+80	24+73	88.5	85.5 m
2	23+80	24+73	85.5	80.0

Soil Nail Wall #2

Zone	Begin Stationing	End Stationing	Upper Elev.	Lower Elev.
1	27+38	28+40	79.0	74.0 m
2	27+38	28+40	74.0	70.0

Soil Nail Wall #3

Zone	Begin Stationing	End Stationing	Upper Elev.	Lower Elev.
1	30+45	31+15	70.5	65.5 m
2	31+15	32+25	72.5	68.5
3	31+15	32+25	68.5	64.0
4	32+25	33+06	69.0	62.0

Proof test on at least eight (8) sacrificial test nails shall be performed for every one hundred production soil nails. The locations of such proof test locations of pullout tests are shown on the plan. An additional two (2) sacrificial test nails for every one hundred production soil nails may be necessary during construction for further quality assurance. Locations of both the proof testing and verification testing shall be chosen in such a manner that the entire limits of the wall is covered, particularly where significant changes in the ground condition and soil/rock characteristics are expected. The pullout test procedure described in the standard special provisions shall be followed. If the test nails fail to meet the requirements stated in the special provisions, the OGDW shall be contacted immediately for assessment of the failure and modification of the wall design, if necessary.

C. Wall Drainage System

Although ground water was not encountered during drilling operations (based on the boring logs), still, to protect against any possible hydrostatic pore pressure build up behind the wall and to direct the surface runoff away from the wall, we recommend constructing a proper internal and external drainage system. For these drainage systems, we recommend the following:

i. Internal Drainage System

- Place 0.30 m wide prefabricated geotextile drain strips (placed with the geotextile side against the ground) vertically on 1.50 m centers prior to applying shotcrete. The geotextile drain strips shall start from the bottom of the proposed gutter and end at the bottom PVC pipe weep hole as shown on the attached Exhibit A.

- Install PVC pipe (51 mm to 76 mm in diameters) weep holes through the shotcrete face at the center and base of the prefabricated geotextile drainage strips were shown on the attached Exhibit A.

ii. External Drainage System

- A concrete drainage gutter may be needed from the beginning of the wall to the end of the wall to collect the surface water away from the wall. Refer to the attached Exhibit A for the location of the gutter. The gutter should be sloped as shown on the plans.

- A Drainage Inlet (DI) or a downdrain is needed at the beginning and end of the wall to collect the surface runoff from the proposed gutter.

- The District Hydraulics Branch should be contacted for specific drainage recommendations.

D. Wall Facing System

The design of the wall facing system is the responsibility of the Office of Structures Design (DSD) and Landscape Architecture Branch.

VI. CONSTRUCTION CONSIDERATIONS

Based on the submitted plans and cross sections, it appears that during construction, the bench that is usually provided by the typical sequence of excavation to construct soil nail walls will not be wide enough (12'±) for the top two rows of Walls #1, #2 to place the drilling equipment. Also, because of the significant number of the existing trees on the slope above the slide and R/W issues for Walls #1 and #2, accessibility from the slope

above the road to construct the wall will be limited. Thus, construction of Walls #1 and #2 may have to be from roadway side only, possibly by using a crane to lift the drilling equipment, or other methods proposed by the Contractor and approved by Caltrans until the bench would be wide enough to place the equipments.

The Contractor will not be allowed to change final wall alignment to construct a wider bench.

VII. CORROSION

Corrosion studies are conducted in accordance with the requirements of California Test Method No. 643.

The Department considers the site to be corrosive to foundation elements if one or more of the following conditions exist for the representative soil and/or water samples taken at the site:

> Chloride concentration is greater than or equal to 500 ppm, sulfate concentration is greater than or equal to 2000 ppm, or the pH is 5.5 or less.

The soil resistivity values range from 475 to 4500 ohm-cm. The pH values ranges between 5.6 and 7.1. Chloride concentration range between 15 and 161 ppm and sulfate concentration range between 23 and 59.

Based on the laboratory test results on the soil samples, the site appears to be non-corrosive

Corrosion mitigation measures should be designed using these test results according to the guidelines provided in the Structure Reference Specification 19-660 (19NAIL).

Should you have any questions, please call Mohammad Zabolzadeh/Ali Kaddoura at (510) 286-4831/4676 or Hooshmand Nikoui, Branch chief at (510) 286-4811.

c: TPokrywka, HNikoui, MZabolzadeh, AKaddoura, SPatch/CCashin, Daily File, Route File

MZabolzadeh/ak/283801 New Soil Nail Report